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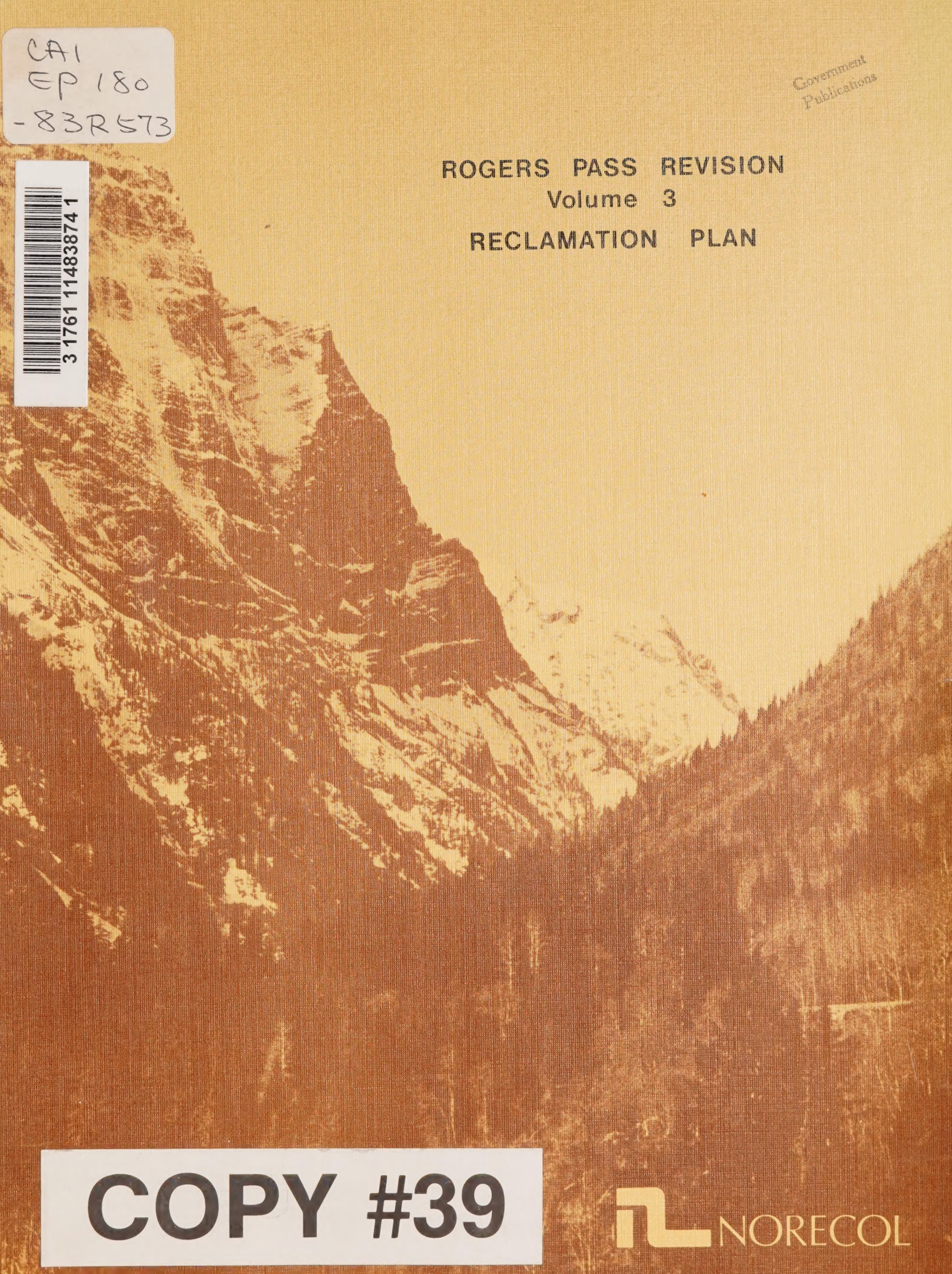
ROGERS PASS REVISION
Volume 3
RECLAMATION PLAN



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ROGERS PASS REVISION
Volume 3
RECLAMATION PLAN

Report
to
CP RAIL
SPECIAL PROJECTS

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NORECOL ENVIRONMENTAL
CONSULTANTS LTD.

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File : 30-10-3A

CALGARY EDMONTON VANCOUVER VICTORIA

EXECUTIVE SUMMARY

Surface reclamation along the Rogers Pass Revision will be the major means of impact mitigation for the terrain disturbances. This report details the proposed reclamation procedures for the surface grade and other disturbances associated with grade construction. A reclamation plan has been developed for the rapid revegetation of exposed, erodible materials with agronomic grass/legume seed mixtures. Following establishment of initial vegetation cover, native trees and shrubs will be planted to develop a self-sustaining vegetation cover. These measures will help to mitigate the visual impacts of the grade by providing a green colour and a visual texture similar to the surrounding slopes.

The materials proposed for use in the reclamation program are outlined in this report. An assessment of growth media suitability for plant growth has been prepared. Results indicate that most of the materials which will be used for constructing the grade are suitable for plant growth. However, materials, such as the deltaic and kame terrace sands and gravels, are not well suited for plant growth. A system of top dressing these less suitable soils has been proposed. Plant species for the proposed program have been selected based on their ability to perform the desired functions such as erosion control and aesthetic improvement.

There is a variety of reclamation methods outlined in the plan which are appropriate for specific uses in the reclamation of the grade. The proposed reclamation program has been been designed to minimize the need for on-going maintenance of the reclaimed sites. However, these will be sites, where maintenance such as fertilizer applications, re-seeding or

replanting of trees and shrubs will be necessary to achieve a satisfactory level of reclamation success. The program for determining reclamation maintenance needs is outlined in the report.

Scheduling of the reclamation work is critical to the success of the program. Two periods, an early spring and a late fall period, are best for seeding vegetation. Planting of trees and shrubs should be restricted to the early spring. In all cases, reclamation work is planned to commence as soon as possible during or after construction.

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1.0 INTRODUCTION

Reclamation of surface disturbances along the Rogers Pass Revision and sound engineering design are the major means of mitigating impacts associated with terrain disturbances. Preliminary reclamation concepts were developed for inclusion in the Rogers Pass Project Brief (CP Rail, 1982). Reclamation investigations have been conducted since the Brief was submitted on April 4th, 1982 to provide details required to adequately plan reclamation of the grade.

This report outlines the detailed reclamation plans for the grade. Details of growth materials salvage and utilization and revegetation plans are presented. Details of the reclamation trials conducted to date are presented in Appendix A.

Reclamation objectives for the grade revision and associated disturbances entail:

- the revegetation of exposed erodible materials to minimize erosion and subsequent water quality degradation;
- amelioration of the visual impact of cuts and fills through the use of vegetation;
- establishment of self-sustaining vegetation cover which is compatible with the naturally occurring vegetation in the area; and

- the use of native species which occur in the Park, where this does not compromise the other objectives.

2.0 RECLAMATION PLANS

2.1 Surface Grade

Reclamation of the cut and fill slopes of the surface grade will be the major reclamation effort. Two phases of reclamation, outlined in the following sections, will be conducted: initial erosion-controlling reclamation, and final establishment of a permanent cover. Generalized reclamation concepts for most of the grade and detailed plans for several major cut and fill areas are presented.

2.1.1 Initial reclamation

Construction of the surface grade will disturb the land surface and create a potential for erosion of the disturbed materials. Revegetation of completed sites with a rapidly establishing agronomic grass/legume cover at the end of each construction season, will reduce the potential for adverse erosion and provide a rapid amelioration of visual impacts.

In order to ensure erosion control and visual impact mitigation for the initial years following completion of construction, all cut and fill slopes will be seeded to provide a rapidly-establishing grass/legume cover. Evaluations of seeded grass/legume stands in the Rogers Pass were made during the 1982 reclamation trials. The results indicated that stand vigor decreased after only a few years unless the stand had been maintained with added fertilizer. Some species, however, such as Creeping Red Fescue appear to persist for 15 years or more on favourable sites. Seeded

species have not been found on undisturbed sites adjacent to revegetated sites, indicating that encroachment of seeded species into the native flora is not a problem.

Native grasses and legumes are not a significant part of the undisturbed flora of Glacier National Park in the area of the grade revision. The use of agronomic species of grasses and legumes for the initial phase of the grade reclamation program is considered to be the most practical means of rapidly establishing a vegetation cover. This initial cover will provide erosion control and visual impact mitigation until the final cover of trees and shrubs (see below) becomes established. It is expected that this initial cover, which is relatively shade intolerant, will not survive once the final cover becomes firmly established.

In addition to initial erosion control and the amelioration of visual impacts, the grass/ legume cover will enhance the substrate by increasing the levels of organic matter and nitrogen. Decomposition of the roots of perennial grasses and legumes can add significantly to soil organic matter. Roots also aid in the development of soil structure and other desirable physical characteristics. Nitrogen fixation by legumes can reduce the need for repeated applications of nitrogen. Rates of nitrogen fixation for alfalfa and alsike clover have been reported as 140 lb/ac to 250 lb/ac (Brady, 1974).

2.1.2 Final reclamation

Final reclamation design has been developed to control

erosion and ameliorate the visual impact caused by cuts and fills. The design incorporates development of a self-maintaining cover of woody species native to Glacier National Park.

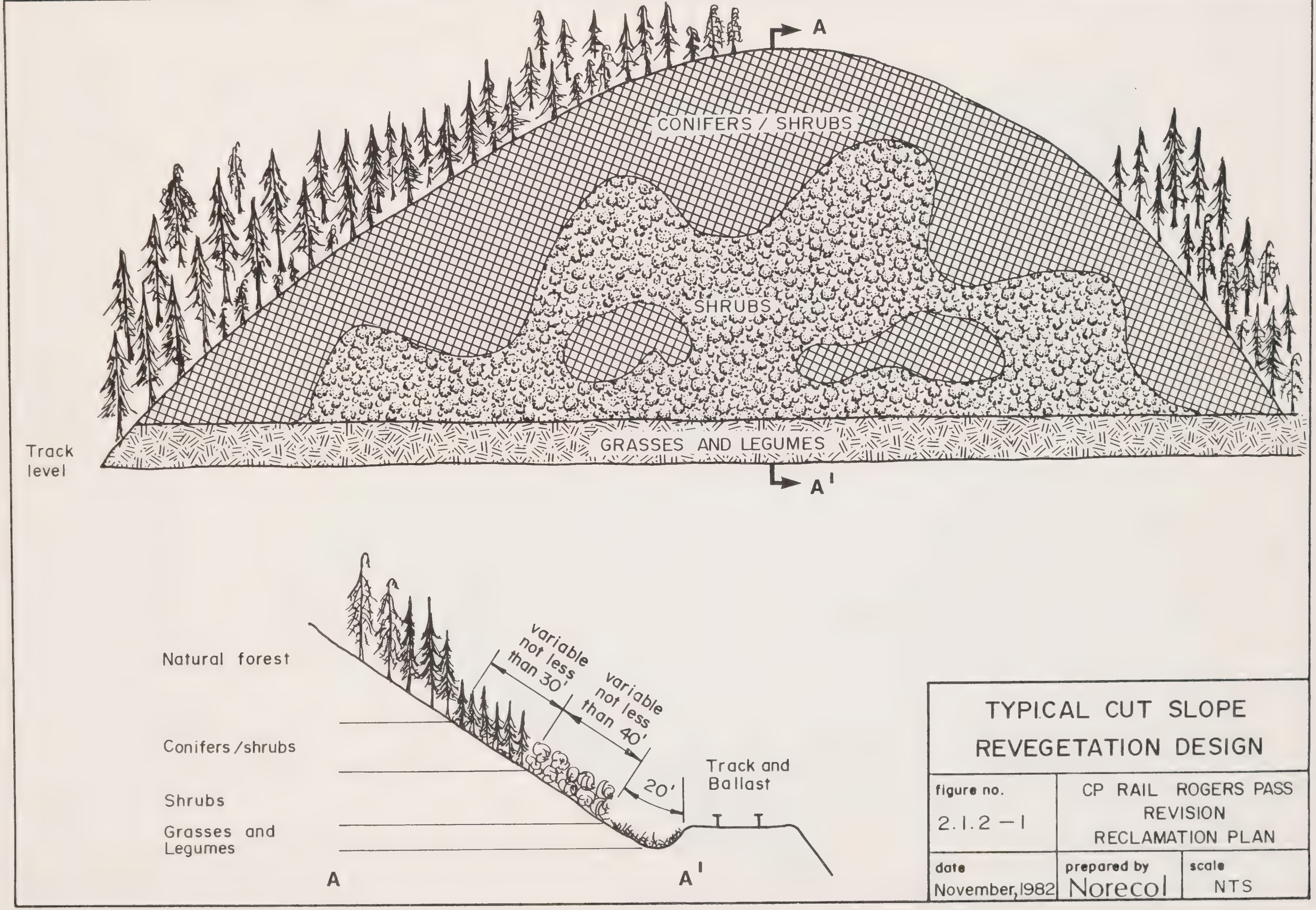
A permanent vegetation cover on disturbed sites will entail planting trees and shrubs. Planting design has two major design objectives:

- Mitigation of visual impacts created by cuts and fills by establishing trees and shrub species found locally in appropriate planting patterns.

- Establish an initial cover of grasses and legumes immediately adjacent to the tracks, particularly on the cut-slopes, because the development of woody species could cause maintenance problems on the railway.

Figures 2.1.2-1 and 2.1.2-2 show the concept design for revegetation along the grade. On sites where the grade traverses openings in the forest cover, such as avalanche tracks, coniferous trees would not be used. The design for these sites would duplicate the cover of the surrounding vegetation, consisting of a herbaceous/shrubby slide path.

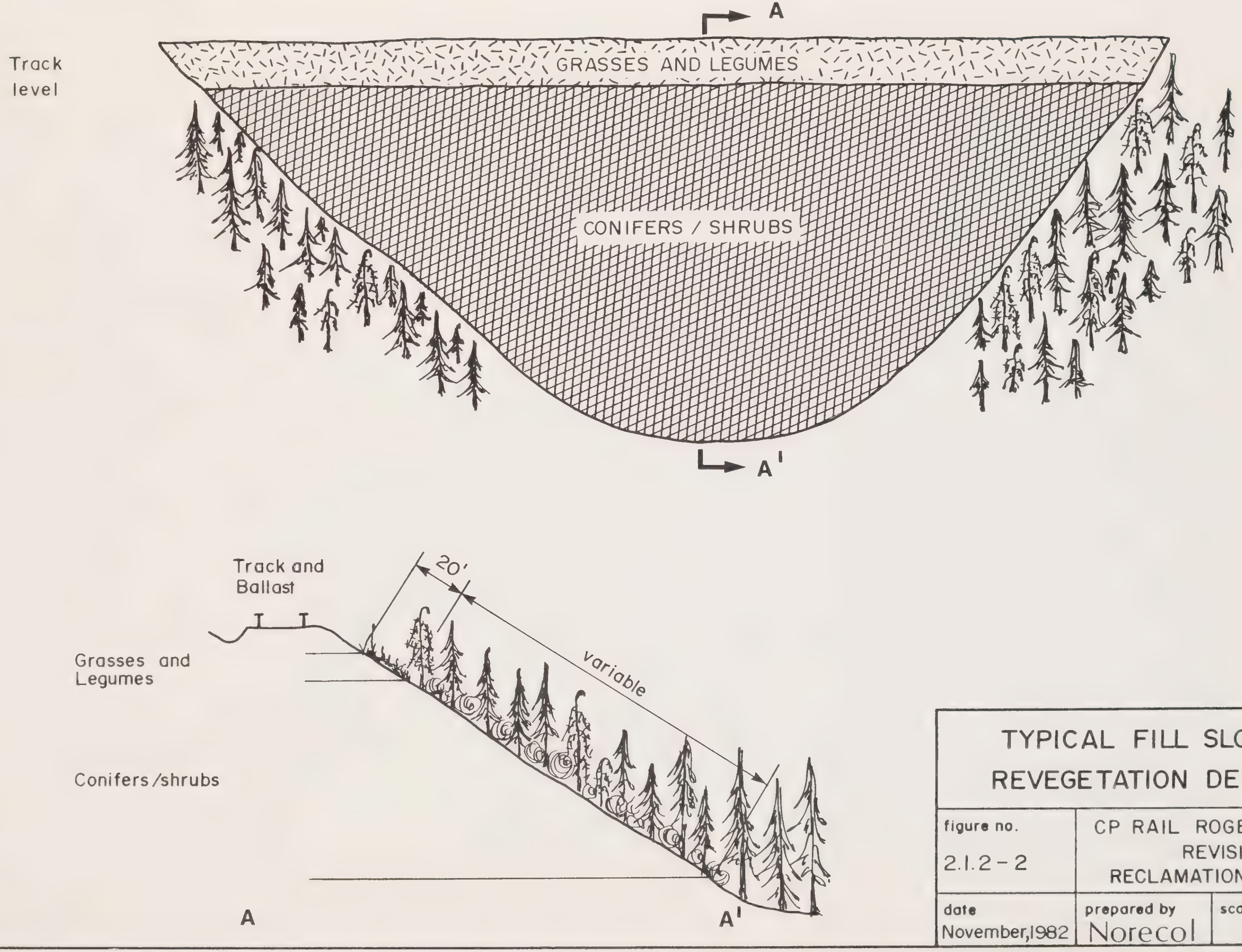
Concept design for large fills such as those at Griffiths and the East Portal were developed and included in the Project Brief (CP Rail, 1982). A system of brush layering was proposed for the East Portal fill. Brush layering is a technique for establishing of shrubs by direct planting of large unrooted cuttings in rows across a steep slope. The



TYPICAL CUT SLOPE REVEGETATION DESIGN

figure no. 2.1.2 – 1	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN

date	prepared by	scale
November, 1982	Norecol	NTS



TYPICAL FILL SLOPE REVEGETATION DESIGN

figure no. 2.1.2 - 2	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN
date November,1982	prepared by Norecol
scale NTS	

feasibility of brush layering is evidenced by the reclamation works on the most recently constructed avalanche shed. This system, however, precludes the use of alder as this species does not root well from hardwood cuttings. As alder is the primary invading species on disturbed sites, a program of planting alder and other woody species is considered the most effective method of developing a permanent cover on the disturbed sites. Brush layering may be used where slopes are excessively steep, similar to those at the avalanche shed site. Current reclamation designs for these, and other large cuts and fills are presented below.

Mountain Creek Pit Cut (Station 150+000 to 164+000

The kame delta at Mountain Creek has been used as a source of gravels for highway construction. The resulting pit will be cut at a slope of 1.75:1 during construction of the current grade revision. Reclamation of this cut will entail surface dressing with suitable fine textured materials (see Section 3.1), initial revegetation with the grass/legume seed mixture, and the planting of trees and shrubs.

Surface dressing will be applied to the Mountain Creek pit cut to a depth of one foot. This material will be placed as the cut is constructed to ensure ease of access. The top dressed surface will be left in a rough condition with small horizontal ridges to help vegetation establishment.

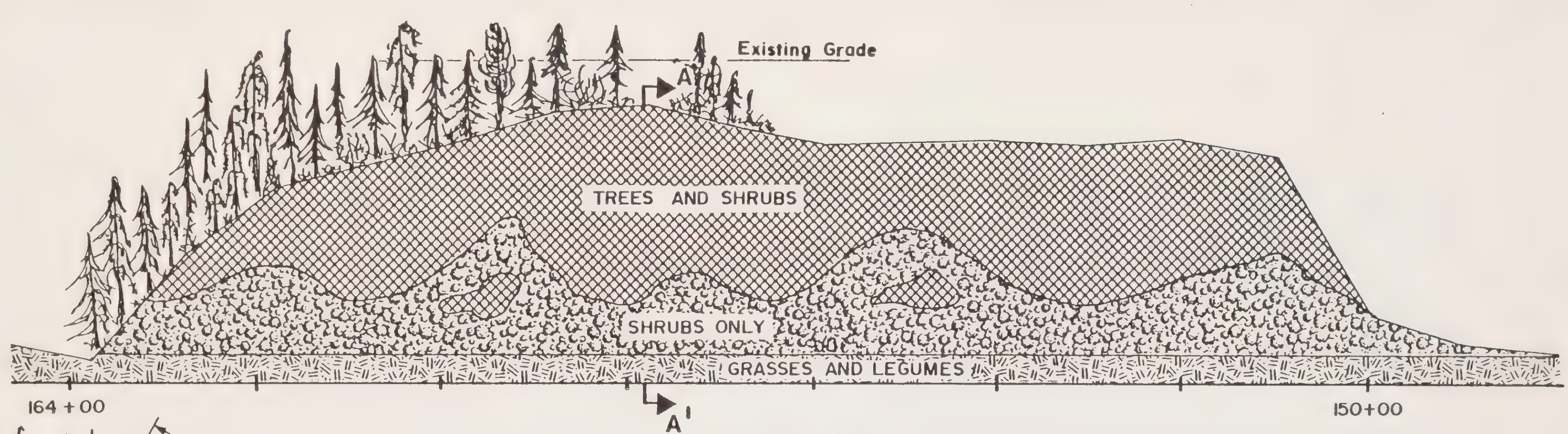
The construction of this cut is expected to extend over several construction seasons. Revegetation

of the completed portions of the cut will be undertaken at the end of each construction season. This would be limited to a seeded cover of grasses and legumes. Trees and shrubs would be planted in the following spring. Figure 2.1.2-3 shows the reclamation design for the completed cut.

Griffiths and Un-named Slides Fills (Station 214+000 to 240+00)

Large fills will be constructed at the Griffiths and Un-named Slides to provide a stable track bed. As the geotechnical stability of these fills is of prime importance it is likely that relatively coarse textured materials will be used. The top portions of these fills will be visible from the Trans Canada Highway. In addition, the tops of the fills will be exposed to full sunlight while their bases will be shaded by trees for at least a portion of the day.

Reclamation procedures for these fills will entail top-dressing the upper 100 feet (approximately half) of the slopes with suitable growth media. It is likely that this material would be placed during fill construction, although, as the potential for burying the top dressing with the upper fill materials exists, other measures of spreading the growth media such as using a small (D6 size) bulldozer with an anchor may be considered. Revegetation will comprise of an initial grass/legume cover on the slopes followed by shrub and tree planting. Trees such as cottonwood, cedar and hemlock will be planted on the moister sites near the base of the slope. Hemlock, white pine,



PLAN VIEW
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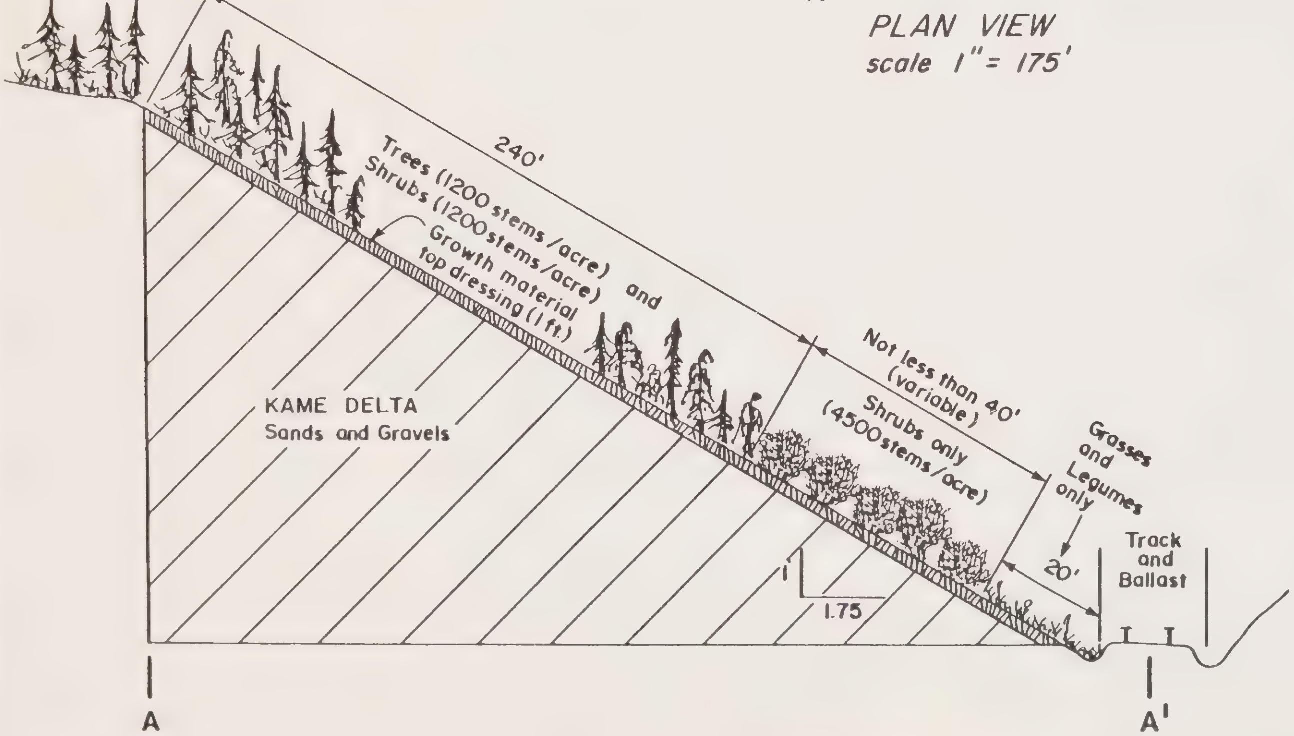


CROSS SECTION
scale 1" = 65'

RECLAMATION PLAN FOR
MOUNTAIN CREEK PIT CUT

Figure no.	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
2.1.2-3		
Date	Drawn by	Scale
FEBRUARY 1983	NORECOL	As shown

spruce and subalpine fir will be planted on the more mesic upslope sites. Figures 2.1.2-4 through 2.1.2-6 show the reclamation design for these sites.

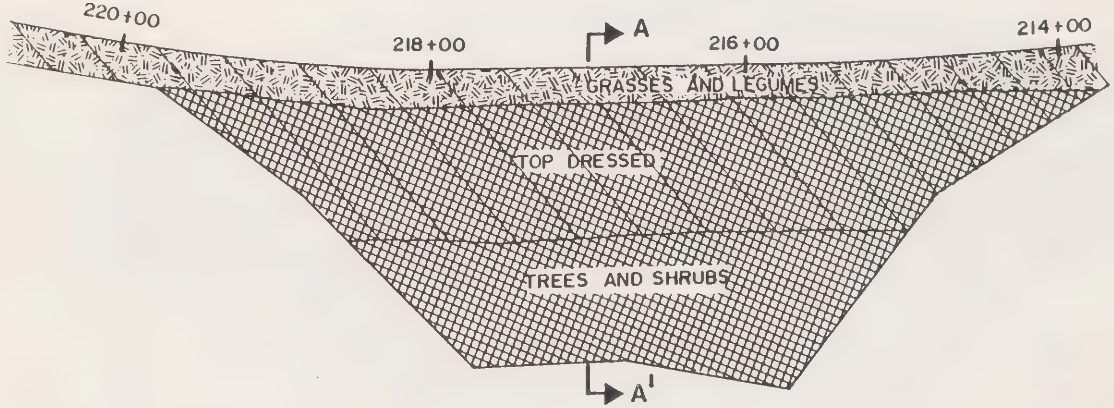
Wet Slide Cuts and Fills (Station 380+000 to 406+000)

Grade construction through the wet slide area will require the use of cut and fill slopes that are flatter than those on other sections of the grade. These cuts and fills will be visible from the Trans Canada Highway. The materials comprising the wet slide area are suitable for plant growth, therefore no top dressing will be applied. Site preparation will include a rough surface for seed germination. On shallow slopes, micro-sites could be provided by the cleat marks of a low ground pressure bull-dozer used up and down the slope.

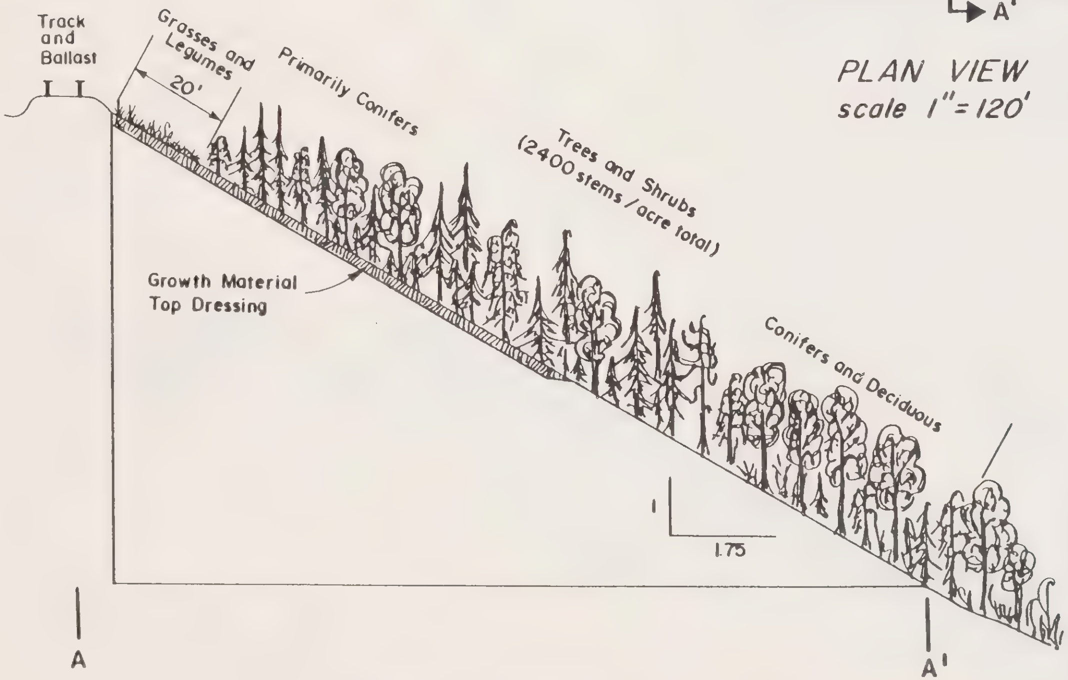
Revegetation of both cut and fill slopes will be initiated by a seeded grass/legume cover. Woody vegetation such as cottonwoods, willows, hemlock and cedar, which draw a large volume of moisture from the substrate, will be used for the final cover. These species will help to dry the slopes and provide greater stability. One acre of deciduous trees, such as cottonwood, has been reported to draw up to 900,000 gallons of water per year from the soil (Schiechtl, 1980). Figure 2.1.2-7 shows the reclamation design for the wet slide area cuts and fills.

East Portal Fill (Station 564+00 to 576+000

Blasted rock from both the short and long tunnels will be used to fill an abandoned gravel pit located

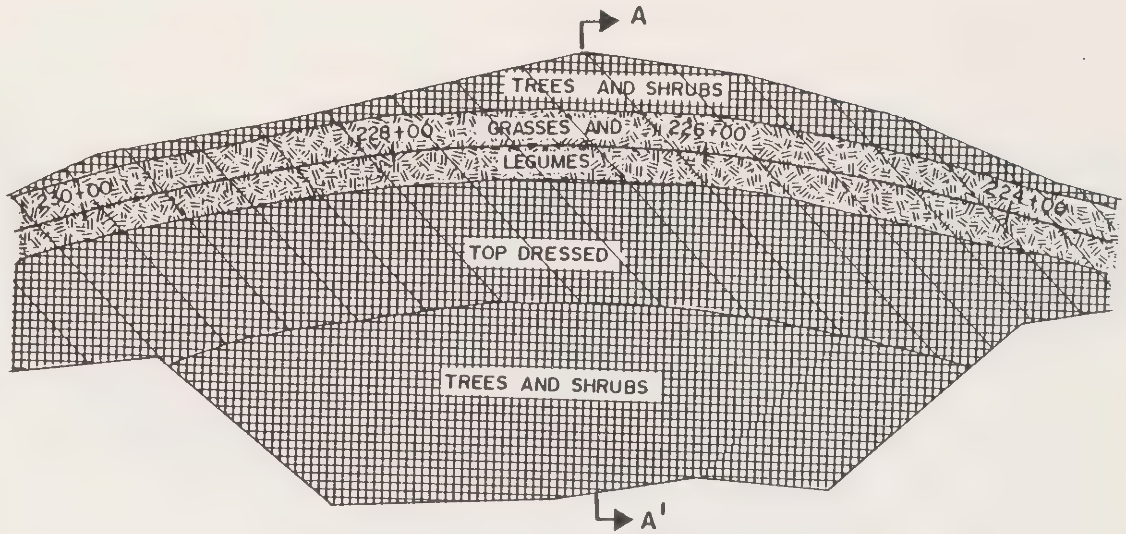


PLAN VIEW
scale 1" = 120'



CROSS SECTION
scale 1" = 35'

RECLAMATION PLAN FOR GRIFFITHS SLIDE FILL		
Figure no. 2.1.2-4	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
Date FEBRUARY 1983	Drawn by NORECOL	Scale As shown



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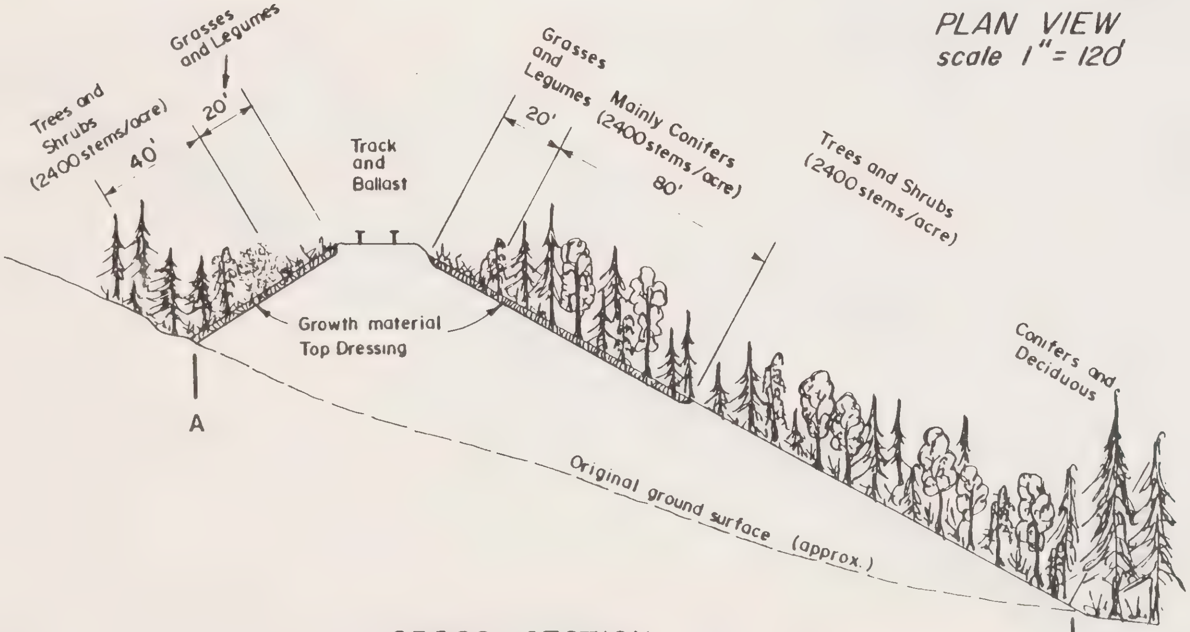
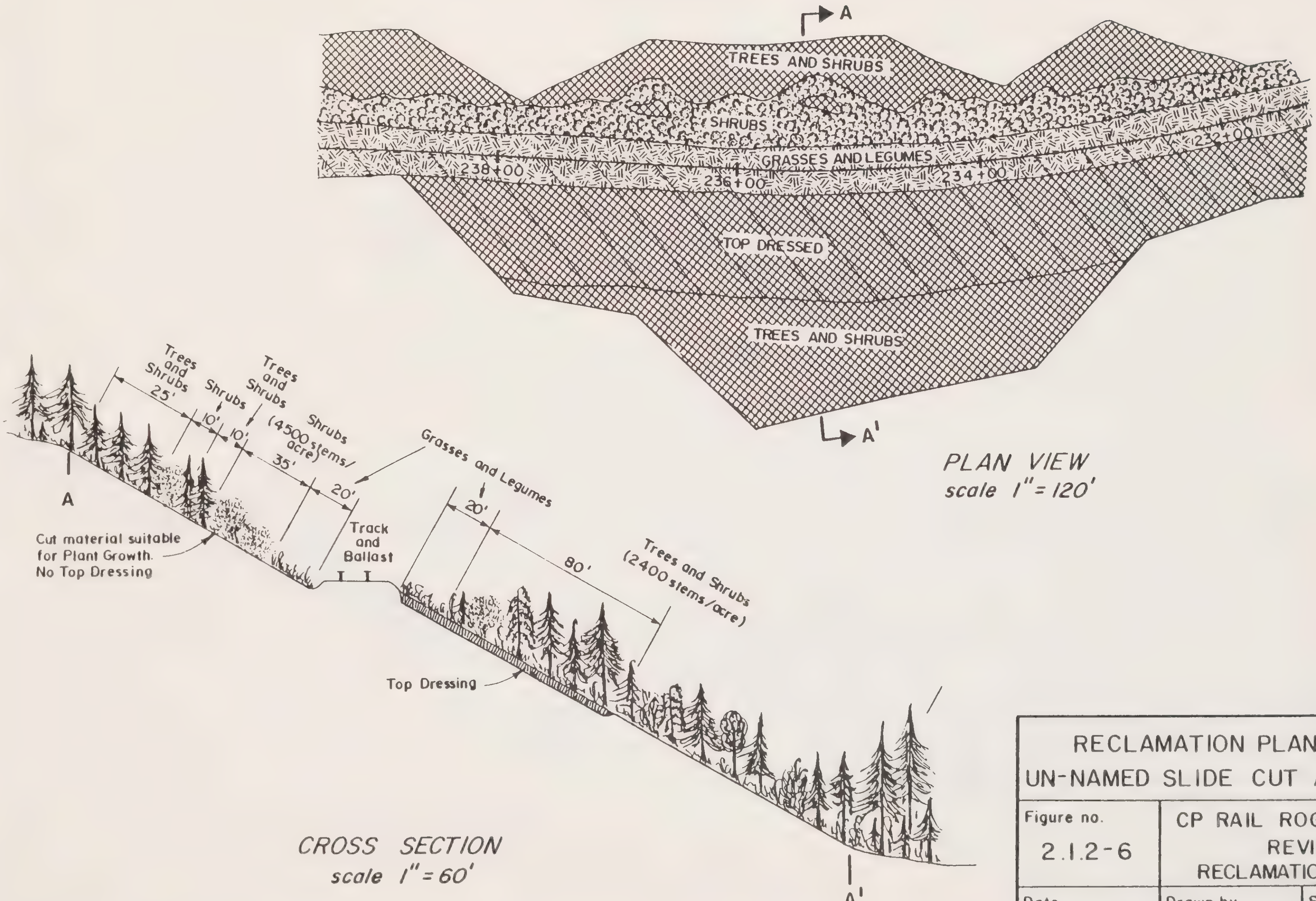


CROSS SECTION
scale 1" = 65'

RECLAMATION PLAN FOR FILL BETWEEN
GRIFFITHS & UN-NAMED SLIDES

Figure no.	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
2.1.2 - 5		
Date	Drawn by	Scale
FEBRUARY 1983	NORECOL	As shown

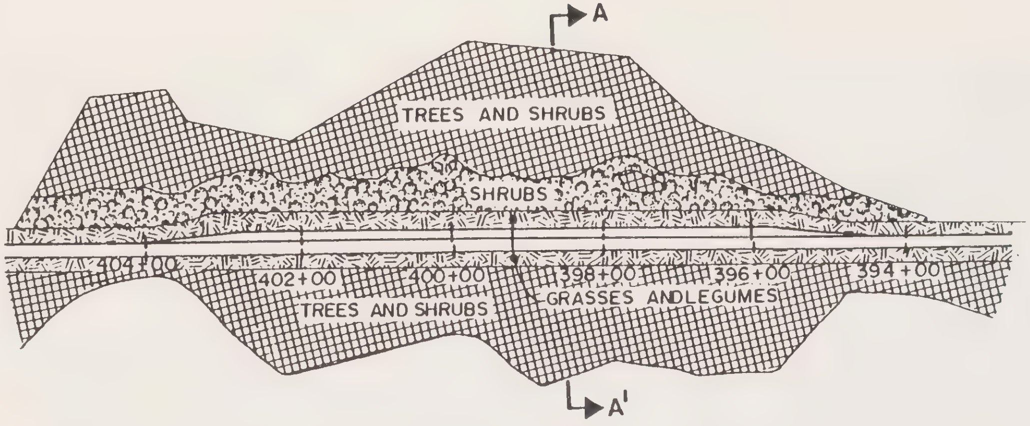


PLAN VIEW
scale 1" = 120'

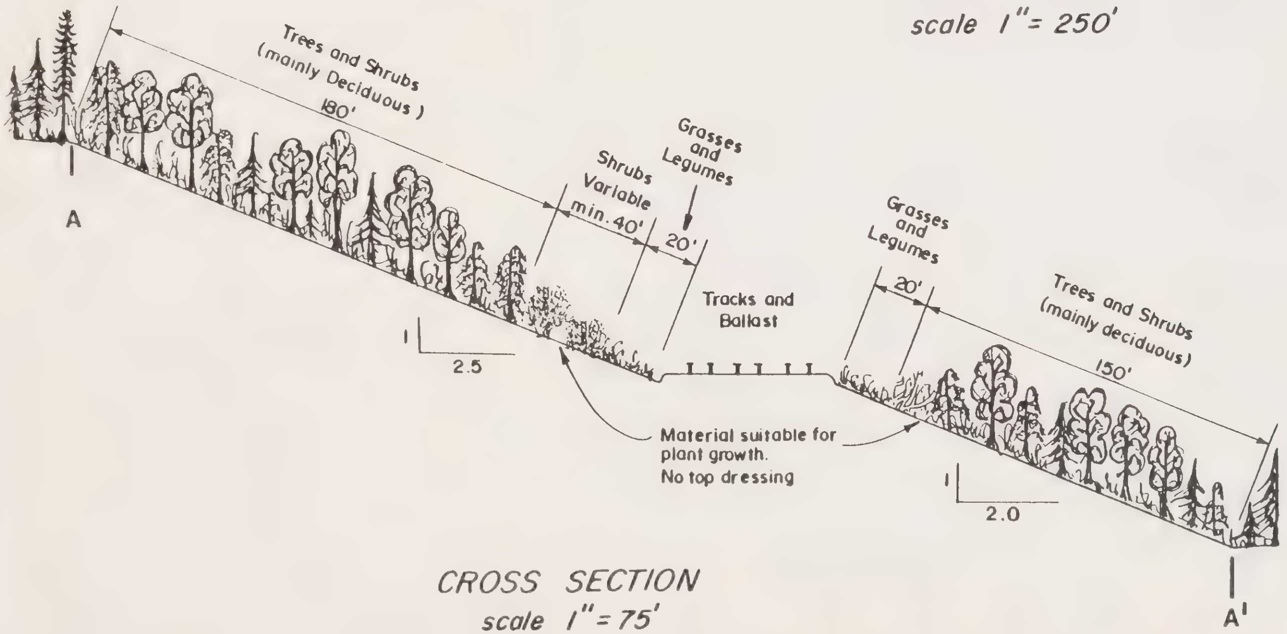
CROSS SECTION
scale 1" = 60'

RECLAMATION PLAN FOR
UN-NAMED SLIDE CUT AND FILL

Figure no.	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
2.1.2-6		
Date FEBRUARY 1983	Drawn by NORECOL	Scale As shown



PLAN VIEW
scale 1" = 250'



CROSS SECTION
scale 1" = 75'

RECLAMATION PLAN FOR WET SLIDE AREA CUTS AND FILLS

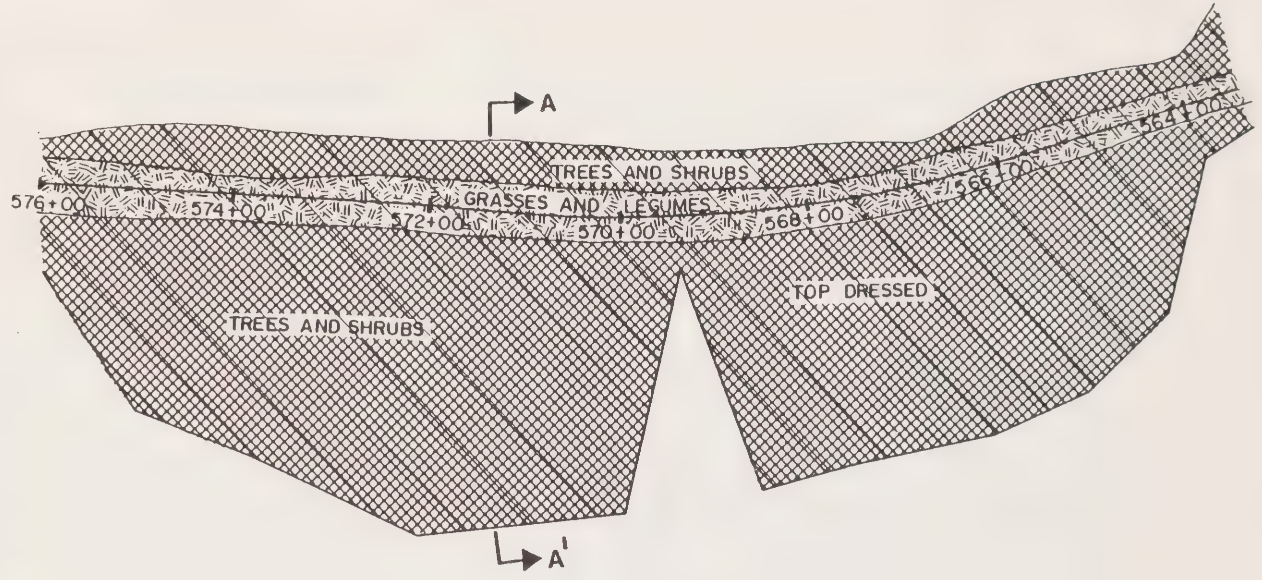
Figure no.	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
2.1.2-7		
Date FEBRUARY 1983	Drawn by NORECOL	Scale As shown

between the two tunnels. There is sufficient pit capacity to accommodate the volumes of waste rock to be generated. This rock will be mainly minus 24 inch size class and will require top dressing to ensure adequate re-vegetation. Due to limited quantities of suitable material along the right-of-way between the two tunnels, the top dressing layer will be limited to six inches. Assessments of rock fill slopes along the Trans Canada Highway such as those adjacent to the Mountain Creek campground access road, indicate that weathering of the coarse fragments breaks them down into materials capable of supporting plant growth.

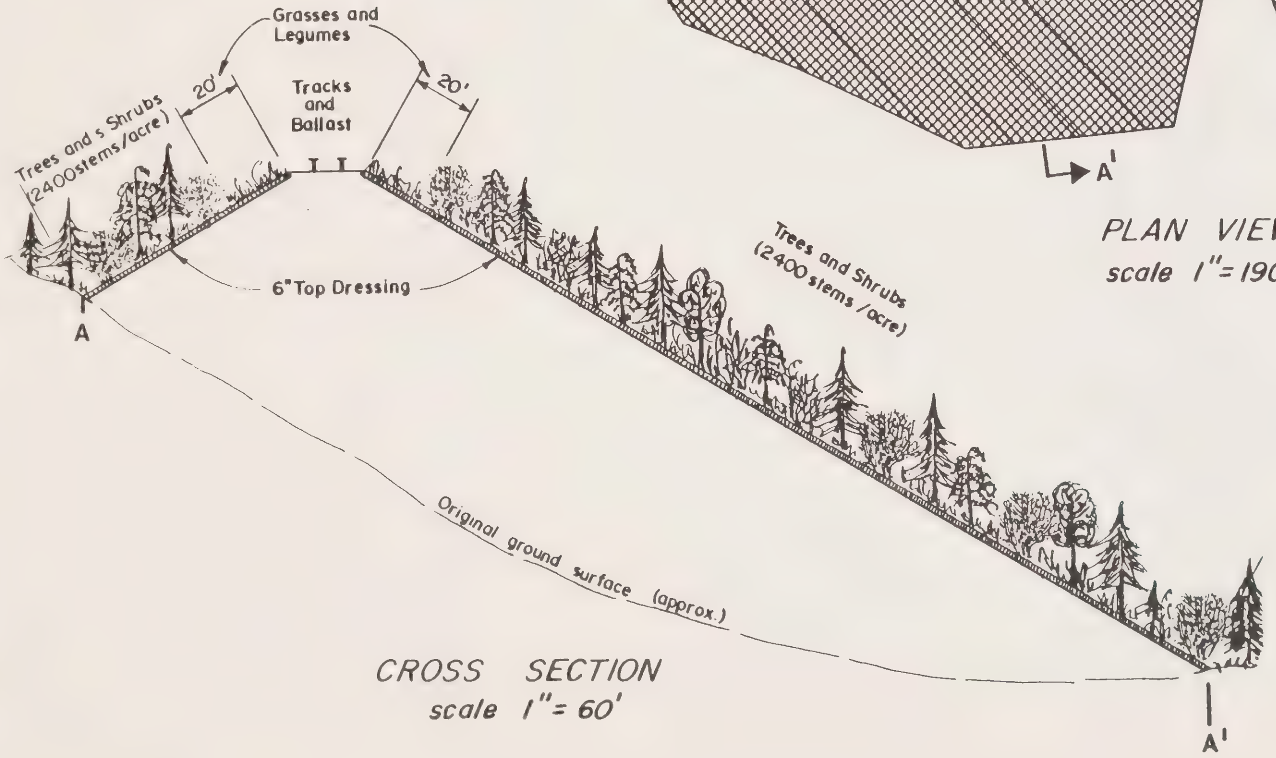
Top dressing would be placed on the slopes as construction proceeds, unless an alternative method of access is provided. The dressed slopes will be left in a roughened state to assist seed germination. Initial revegetation will be a seeded grass/legume cover followed by planting of trees and shrubs. Species such as alder, hemlock, spruce and subalpine fir will be used. Figure 2.1.2-8 shows the currently proposed reclamation design for the East Portal fill. Tunnel construction will take several years consequently, stockpiling of top dressing materials may be necessary. A temporary vegetation cover on the top dressing storage piles would be desirable to prevent excessive erosion.

2.2 Access Roads and Trails

Access roads have been and will be developed to support work along the grade and at other sites. Reclamation of these roads will commence upon completion of their use.



PLAN VIEW
scale 1" = 190'



CROSS SECTION
scale 1" = 60'

RECLAMATION PLAN FOR
EAST PORTAL FILL

Figure no. 2.1.2-8	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN

Date	Drawn by	Scale
FEBRUARY 1983	NORECOL	As shown

Reclamation of access roads will require road regrading to conform to the shape of the local ground surface. A large backhoe is an effective tool for recontouring roads. Where the surrounding topography is level and regrading is not required, the running surface will be ripped to a depth of one foot to reduce compaction. The surface should be left in a roughened condition to prevent off-highway access by unauthorized personnel.

Revegetation of abandoned access roads will consist of a vegetation cover similar to that existing prior to construction. In most cases, this would be an initial cover of grasses and legumes followed by tree and shrub plantings.

Access trails to drill holes and test pits have been constructed along the surface grade. Where these lie outside the area of disturbance by grade construction, the original surface contours will be re-established. All of these trails will be revegetated using an erosion-controlling grass/legume seeding and the plantings of trees and shrubs.

2.3 Camps and Other Facilities

Two construction camps to house the construction work force are planned. Development of the camp sites at Flat Creek and Beaver will result in about 10 acres of surface disturbance. Reclamation of these sites will be undertaken in two phases. An initial phase immediately following construction will entail the establishment of a temporary grass/legume cover on those areas of the camps where further disturbance is

unlikely. This cover would provide a lawn area around the camps and reduce erosion. Furthermore the cover would provide a pleasing environment for camp residents.

The second phase would begin following the completion of construction, at which time, the camps will have been removed from the sites. All concrete or paving will be ripped and removed or buried. The sites will be ripped and regraded to conform with the local topography, providing that this does not disturb sites previously reclaimed. The sites will then be seeded with a grass/legume seed mix followed by the planting of trees and shrubs.

3.0 RECLAMATION MATERIALS

The availability and use of suitable reclamation materials, including soil or growth media and plant stocks, is outlined in the following section. As the project proceeds, further information regarding materials suitability will be obtained, therefore, this outline is intended to serve as a guide rather than as a constraint for future reclamation programs.

3.1 Soil and Surficial Materials

The soil and surficial materials along the Rogers Pass Revision were assessed and sampled in October 1982. Samples were taken from materials of various landform types and from weathered surface and unweathered subsurface materials. These samples were returned to the laboratory and tested for selected chemical and physical properties. Appendix B details the results of the chemical analyses. The particle size and texture of these materials are also listed in Appendix B. Additional particle size and textural data obtained from surface samples collected by Thurber Consultants Ltd., are listed in Appendix C.

3.1.1 Material texture

The texture class assigned to a soil material is based upon the proportions of sand, silt and clay sized particles it contains. Coarse textured soils such as sands and loamy sands contain 70% or more sand particles by weight. These soils drained rapidly and have a low water and nutrient holding capacity. Medium textured soils, for example sandy loams, loams

and silt loams are a more even mixture of sand and clay sized particles. They have moderate water and nutrient holding capacities and good drainage. Fine textured soils like clay loams and clays have very high water and nutrient holding capacities but are often poorly drained and aerated.

Most of the morainal and kame moraine materials in the area have a sandy loam texture, therefore they have the capability to hold sufficient moisture and nutrient to support good plant growth. The kame terrace and fluvial materials are generally loamy sand or sand textures and therefore subject to droughtiness and poor nutrient retention. Glaciolacustrine materials have silt loam textures and are the best soil materials for plant growth.

3.1.2 Plant nutrient supply

The ability of a soil to supply nutrients for plant growth is controlled primarily by its content of organic matter and clay particles. These two materials adsorb nutrients and prevent their loss through leaching. The soils in the Rogers Pass Revision are typical of many forest soils; they are coarse textured and have a low organic matter content. Nutrients must be added to support good plant growth.

Most of the area soils have a pH of 5.5 to 6.0. This is suitable for plant growth as most nutrients are readily available within this pH range. Some of the deltaic and debris cone deposits have a pH range of 6.6 to 7.0, and elevated levels of calcium which lowers the capability of the soil to retain other nutrients. Such

materials will be more difficult to revegetate since much of the nutrient content added by fertilizers will not be retained by the soil particles. However, these soil materials do not have as high pH or calcium levels as do the soils in the Mountain Creek cut slope on the existing grade. This latter site has been successfully revegetated, although it will require future application of fertilizer.

In general the area soils contain low levels of nutrients typical of many forest soils, and fertilizer applications will be necessary to develop good plant growth.

3.1.3 Suitability of soil and surficial materials for reclamation

The suitability of the soil and surficial materials for use in the reclamation program was assessed on the basis of their texture, nutrient retention characteristics and the occurrence of any substances which could be deleterious to plant growth. The entire route has been subdivided into landform units (Thurber Consultants Ltd., 1983 Volume 1) and the surficial material in each of these units was assessed for reclamation suitability (Table 3.1.3-1). Glaciolacustrine materials were classed as having a high suitability for reclamation because of their fine texture and high water holding capacity. Morainal and kame moraine materials were classed as moderately suitable for reclamation due to their sandy loam texture. Kame terraces, and deltaic deposits were classed as having a low suitability for reclamation

TABLE 3.1.3-1

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE		COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
	FROM	TO					
1	0+00	15+00	FLOODPLAIN OF BEAVER RIVER AND CUPOLA CREEK (INCLUDES ACTIVE FLOODPLAIN OF CUPOLA CREEK): consists of coarse gravel.			low	no
2	15+00	36+40	GLACIOLACUSTRINE OR ALLUVIAL PLAIN: consists of laminated silt and silty sand with localized knobs of crossbedded gravel and sand.	Silt loam	moderate	high	yes
3	36+40	41+20	TERRACE ADJACENT TO ALDER CREEK: consists of gravel.			low	no
4	41+20	50+00	FLOODPLAIN OF ALDER CREEK (INCLUDES ACTIVE FLOODPLAIN): consists of coarse gravel.			low	no
5	50+00	62+80	TERRACE ADJACENT TO ALDER CREEK: consists of gravel.	Loamy sand	low	low	no
6	62+80	68+20	GLACIOLACUSTRINE OR ALLUVIAL PLAIN - SOME ROCK KNOBS: consists of laminated silts draped over massive quartzite.	Silty loam	moderate	high	yes
7	68+00	82+00	KAME TERRACE: consists of gravel and sand.			low	no

1 of 6

TABLE 3.1.3-1 (continued)

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE FROM	CHAINAGE TO	COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
8	82+00	96+50	COLLUVIAL SLOPE - SOME ROCK KNOBS: soils consist of a mixture of gravel and sand of glacial origin, gravel originating as ballast or fill from existing CPR line, blocks which have slabbed off bedrock exposures, roots, trees. Bedrock includes massive quartzite and grit and thin bedded micaceous quartzite and schist.			low	no
9	96+50	109+00	ROCK: consists of massive quartzite with a discontinuous, very thin colluvial soil cover.	Silt loam	low	Not Applicable	
10	109+00	131+20	KAME TERRACE: consists of gravel and sand.	Sandy loam/ Silt loam- in pockets	low, moderate levels of phosphorus	low	no
11	131+20	144+80	FLOODPLAIN OF MOUNTAIN CREEK (INCLUDES ACTIVE FLOODPLAIN): consists of very coarse gravel.	Loamy sand	low, moderate levels of calcium	low	no
12	144+80	150+60	TERRACE ADJACENT TO MOUNTAIN CREEK: consists of coarse gravel.	Sand		low	no
13	150+60	168+14	KAME DELTA (MOUNTAIN CREEK SOURCE) - SOME ROCK: consists of coarse gravel draped over knobs of massive quartzite. Covered from 163+50 to 168+14, but assumed to be similar.	Sand/ Sandy loam		low	no

TABLE 3.1.3-1 (continued)

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE FROM	TO	COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
14	168+14	179+00	KAME MORAINE VENEER OVERLYING ROCK: consists of poorly sorted sand and gravel with a discontinuous silty sand cover, all overlying bedded micaceous quartzite and schist.	Silt loam/ Silt		moderate	no (too shallow)
15	179+00	215+90	KAME MORAINE - SOME ROCK: consists of dirty sand and gravel, limited till, discontinuous thinly draped silt deposits. Occasional bedded micaceous quartzite and schist.	Sand/ Loamy sand/ Sandy loam/ Silt loam	low, pH 4.9	moderate	yes
16	215+90	217+40	SLUMP MATERIAL IN THE GRIFFITH SLIDE ACTIVE LOBE: consists of till-like soil.			moderate	no (fill area)
17	217+40	229+00	KAME MORAINE - SOME ROCK: consists of poorly sorted sand and gravel, limited till and one outcrop of micaceous quartzite in gulley at 227+00.	Sand	low	moderate	no
18	229+00	249+00	SLUMP MATERIAL IN THE UNNAMED SLIDE: consists of till-like soil with angular blocks - locally with a closed structure.	Sandy loam	low, moderate levels of phosphorus	moderate	yes (in cuts only)
19	249+00	266+20	KAME MORAINE VENEER OVERLYING ROCK: consists of thin, dirty sand and gravel and limited till overlying quartzites and schists.	Loamy sand		moderate	no (too shallow)
20	266+20	270+50	DEBRIS CONE OF CEDAR CREEK: consists of a coarse, silty sandy gravel.	Loamy sand		moderate	no

TABLE 3.1.3-1 (continued)

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE FROM	TO	COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
21	270+50	291+50	KAME MORAINE VENEER OVERLYING ROCK: consists of thin, poorly sorted sand and gravel and limited till overlying schists.	Sandy loam	low	moderate	no (too shallow)
22	291+50	293+00	KAME DELTA (RASPBERRY CREEK SOURCE) OVERLYING ROCK: consists of gravel overlying quartzites and schists.			low	no
23	293+00	294+00	FLOODPLAIN OF RASPBERRY CREEK (ASSUMED TO BE ALL ACTIVE): consists of coarse gravel.			low	no
24	294+00	307+50	KAME DELTA (RASPBERRY CREEK SOURCE) - SOME ROCK: consists of gravel and sand with discontinuous, thinly draped silt deposits and some till all overlying thinly bedded micaceous quartzites and schist.	Silt loam/ Loamy sand/ Sand	low	low	low
25	307+50	328+00	ROCK: consists of weak schists with only a topsoil cover.			Not Applicable	
26	328+00	332+80	DEBRIS CONE OF SURPRISE CREEK: consists of silty sandy gravel.	Sand	low, high levels of calcium	moderate	no
27	332+80	339+00	ROCK: consists of weak schists with only a topsoil cover.			low	no
28	339+00	360+60	KAME MORAINE - SOME ROCK: consists of poorly sorted sand and gravel and till overlying schists and micaceous quartzites.	Loamy sand	low, moderate levels of phosphorus	moderate	yes

TABLE 3.1.3-1 (continued)

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE FROM	TO	COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
29	360+60	388+00	LATERAL MORAINE: consists of till with very localized gravel pockets.	Sandy loam/ Loamy sand		moderate to good	yes
30	388+00	400+00	SLUMP MATERIAL IN THE WET SLIDE AREA: consists of wet till-like soil overlain by organic and silt laminae.			moderate	yes
31	400+00	407+00	LATERAL MORAINE: consists of till.	Sandy loam	low	moderate	yes
32	407+00	423+00	KAME MORAINE OR KAME DELTA (STONEY CREEK SOURCE): consists of coarse gravel with an ablation cover of angular blocks.	Loamy sand/ Sandy loam		low	no
33	423+00	427+20	DEBRIS CONE OF STONEY CREEK: consists of silty, sandy gravel.	Sandy loam	low, moderate levels of phosphorous	moderate	no
34	427+20	441+20	LATERAL MORAINE - SOME ROCK: consists of two tills; a stoney ablation till overlying a silty basal till, possibility of stratified gravel and sand separating these two deposits in few locations. Bedded micaceous quartzite and grit exposed in some stream gulleys.	Loamy sand/ Sandy loam/ Loam	low	moderate	yes
35	441+20	468+00	KAME MORAINE OR KAME DELTA (SOPER CREEK SOURCE) SOME ROCK: consists of a discontinuous stoney ablation till overlying stratified gravels, sands and silts, overlying silty till. Bedded micaceous quartzite and grit exposed in some stream gulleys.	Sandy loam/ Loamy sand/ Sand		moderate	no

TABLE 3.1.3-1 (concluded)

MATERIAL SUITABILITY FOR RECLAMATION AND POTENTIAL FOR SALVAGE

LANDFORM NO.	CHAINAGE		COMMENTS[1]	TEXTURE[2]	NUTRIENT STATUS	RECLAMATION SUITABILITY	POTENTIAL FOR SALVAGE OF TOP DRESSING MATERIAL
	FROM	TO					
36	468+00	497+00?	LATERAL MORAINE: consists of two tills; a stoney ablation till overlying a silty basal till.	Sandy loam/ Loamy sand Sand/loam	low, moderate level of phosphorus	moderate	no (to be bridged)
37	497+00	558+00	ROCK - SHORT TUNNEL SECTION AND BRIDGE OVER CONNAUGHT CREEK AT THE WEST PORTAL OF THE SHORT TUNNEL	Not Applicable			
38	558+00	575+50	GLACIOFLUVIAL PLAIN: consists of gravel and sand, locally overlain by clean fine sand. Covered from 558+00 to 560+43, but assumed to be similar.	Sand		low	no
39	575+50	601+00	LATERAL MORAINE: consists of till, locally overlain by silt.	Sandy loam/ Silt loam	low	moderate	yes

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[1] From Thurber Consultants Ltd. 1983, Volume I.
[2] From grain size analysis (Appendix B and C).

6 of 6

due to their coarse texture and elevated levels of calcium.

3.1.4 Potential for salvage of top dressing material

An assessment of the surface soils along the route indicated that they have texture and chemical characteristics similar to the unweathered sub-soil materials (Appendix B). The surface soils are generally Humo-Ferric Podzols with very shallow litter layers and low organic content. Along much of the route the steep slopes will prohibit the selective salvaging of only the weathered material. Therefore, areas of unweathered materials having moderate to high suitability for reclamation which will be excavated in cut slopes or can be salvaged, have been considered as a top dressing for sites possessing a low suitability for reclamation. Many of these suitable materials will be excavated during construction to provide firm foundations for the grade. Portions of the route materials potentially salvageable are shown in Table 3.1.3-1.

3.2 Revegetation Species

Reclamation success will depend, to a large extent, on the selection and use of suitable plant species. The revegetation program is designed to:

- provide initial control of erosion and protection of the soil material;

- provide permanent cover allowing integration of the sites into the natural processes of succession; and

- ameliorate the visual impacts created by construction.

Commercially available grasses and legumes are the most effective means of erosion control and enhancement of soil materials. However, these species do not generally maintain themselves for long, for example, studies of reclaimed sites in southeast B.C. indicate that agronomic species experience significantly reduced vigor after about 10 years.

An evaluation of the revegetation of road cuts along the Trans Canada Highway in the Beaver Valley was made during other studies in the area. The highway was commissioned in 1963. Woody species currently growing on the cuts and fills are a maximum of about 15 years old, indicating that the agronomic cover was sufficiently reduced after about 4 years to allow invasion of native species. Some sites have been completely invaded by native species except along road margins where continual disturbance caused by snow removal and other maintenance activities has allowed the agronomic species to survive.

Agronomic species have been used by Public Works and CP Rail for reclamation throughout Glacier National Park. Table 3.2-1 outlines the species used in the Park.

Two seed mixes have been developed for the initial reclamation of grade in the Rogers Pass Revision on the basis of their suitability for differing sites. Table 3.2-2 presents these two species mixes.

TABLE 3.2-1

AGRONOMIC SPECIES USED FOR RECLAMATION IN GLACIER NATIONAL PARK

	Mountain Creek					
Species	1977[1] %	1978[1] %	1979[1] %	1982 %	Surface Grade 1982 %	Roadsides (% unknown) Found in 1982
Creeping Red Fescue	20	15	25	8.74	13.2	X
Hard Fescue				7.26		
Kentucky Bluegrass	20	15	20	0.98		X
Streambank Wheatgrass				22.12		
Crested Wheatgrass		15	20	18.16		
Orchardgrass	15	10		0.73	8.0	X
Timothy	10	10	10	19.33	36.5	X
Brome Grass		10				X
Perennial Ryegrass	15	10			29.2	
Tall Fescue				S[2]		
Slender Wheatgrass				S		
Canada Bluegrass				S		X
Pubescent Wheatgrass				S		
Redtop		5	5			X
Alsike Clover			5	9.21	13.1	X
Birdsfoot Trefoil				S		
Sainfoin				S		
Crown Vetch				S		
White Dutch Clover	10	5	5			
Vernal Alfalfa	10	5				
Rambler Alfalfa			10	7.17		
Fall Rye	50lb/ac	50lb/ac				

[1] A. Lamb, pers. comm.

[2] S = single species trials

TABLE 3.2-2

REVEGETATION SPECIES MIXES
ROGERS PASS REVISION

Species	Site Type Dry % by wt.	 Moist % by wt.
Creeping Red Fescue	8.74	9.68
Hard Fescue	7.26	
Kentucky Bluegrass	0.98	1.07
Streambank Wheatgrass	22.12	
Crested Wheatgrass	18.16	
Orchardgrass	7.03	7.79
Timothy	19.33	21.43
Redtop		0.87
Slender Wheatgrass		25.12
Alsike Clover	9.21	10.21
Rambler Alfalfa	7.17	23.83
	100.00	100.00

Further evaluation of trials conducted in 1982 may result in modifications to these species mixes.

The ultimate success of the reclamation program will depend on how effectively the disturbed sites can be integrated into the natural successional processes which operate in the park. Evaluations of species which naturally invade disturbed sites can provide clues for the selection of species appropriate for revegetation. In addition, use of naturally occurring successional species will ensure that reclaimed sites are visually compatible with the surrounding vegetation. Edaphic, or site, requirements of native species can be used to determine the site conditions along the planned grade where the species will perform most satisfactorily.

Native or adventive species colonizing disturbed sites fall into the two classes of weeds and native pioneers. Weed species such as pearly everlasting (*Anaphalis margaritacea*), common dandelion, (*Taraxacum officinale*), knapweeds (*Centaurea* spp.) and members of the mustard family (*Brassicaceae*) often invade unreclaimed disturbed sites. These can often become established in the flora of the Park and displace native species. Native pioneers such as alder (*Alnus* spp.), cottonwood (*Populus trichocarpa*), willows (*Salix* spp.), thimbleberry (*Rubus parviflorus*) red-osier dogwood (*Cornus stolonifera*), mountain avens (*Dryas drummondii*) elderberry (*Sambucus racemosa*), and some of the conifers, especially western hemlock (*Tsuga heterophylla*) and western white pine (*Pinus monticola*) can provide the initial permanent cover on

disturbed sites. Table 3.2-3 outlines the native species to be used in reclamation of the grade.

The use of woody species such as cottonwood and alder on seepage sites will aid in removing excess soil moisture. On dry sites, woody pioneers can aid in ameliorating site conditions to allow invasion by climax species.

The two-phased approach comprising initial erosion control revegetation followed by plantings of native woody pioneering species, would ensure that the reclamation program objectives are met. Details of the planting methods and procedures are outlined in the following section.

TABLE 3.2-3

NATIVE SPECIES PROPOSED FOR RECLAMATION
ROGERS PASS REVISION

Species	Site Types Wet Seepage	 Mesic	 Dry	 Avalanche Chutes
Alder	X	X	X	X
Cottonwood	X	X		X
Willows	X	X	X	X
Elderberry	X	X		X
Thimbleberry	X	X		X
Red-osier Dogwood	X			X
Mountain Avens			X	
Western Red Cedar	X			
Western Hemlock	X	X		
Western White Pine		X		
Lodgepole Pine			X	
Douglas Fir			X	
Juniper			X	
Oregon Grape			X	
Kinickinick			X	
Engelmann Spruce		X		
Subalpine Fir		X		

4.0 RECLAMATION METHODS

This section outlines the reclamation methods proposed for surface disturbances associated with the grade revision. Selection of appropriate methods will be based on a site by site analysis as the project proceeds.

4.1 Site Preparation

Site preparation will involve the development of suitable rooting media and surface configurations on the sites to be reclaimed. About two-thirds of the grade will be constructed from materials which themselves, are suitable for plant growth. However, several materials will have a low suitability for reclamation (see Section 3.1). These latter materials include the bouldery and gravelly terrace materials near creeks, tunnel muck from the East Portal, and materials from a small area outside the Park consisting of very coarse colluvium over bedrock.

The feasibility of reclaiming the terrace materials was demonstrated in the 1982 spring trials at Mountain Creek. No trials have been conducted on the coarse colluvial materials or the tunnel muck. However, results of the soils analysis indicate that even the lowest suitability materials on the new grade are better than those at Mountain Creek, with the possible exception of the tunnel muck. The application of suitable materials as a top dressing to these units would improve reclamation potential.

Some top dressing materials for the East Portal fill

have been stockpiled in the abandoned gravel pit adjacent to the site. Materials for top dressing the other sites will be obtained from cuts or sub-excavations. Table 4.1-1 outlines those sites where top dressing application would enhance the reclamation. The utilization of top dressing materials will require careful inspection to insure suitable materials are salvageable and these are applied appropriately. Methods of materials placement will depend upon machinery available and configuration of the slopes. On cuts, backhoes could be used to deposit materials on slopes. On fill slopes a backhoe could spread materials as the fills are constructed. Materials should be placed as cuts and fills are developed while access is available.

Slope designs have been developed for cuts and fills to minimize the total area of disturbance while taking into account geotechnical stability and maximizing the surfaces which can be reclaimed. Revegetation effectiveness is controlled by slope steepness and slope length. On long slopes, grades must be reduced to achieve the same degree of revegetation attainable on short slopes. Small (less than 80 feet) cut and fill slopes will be constructed with an overall grade of 1.5:1 (H:V). Cut and fill slopes longer than about 80 feet will have an overall grade of 1.75:1.

Surface preparation is necessary to provide a suitable seed bed. In most cases seed beds should be rough surfaced to allow the seed to lodge in cracks and crevices as micro-sites for seed germination. It is expected that, by avoiding excessive slope grooming, small horizontal ridges will remain on the slopes.

TABLE 4.1-1
TOP DRESSING UTILIZATION

Station[1]	Volume Required[2] (cubic yards)	Obtained From
0+00 - 62+80	12,455	Silty glaciolacustrine materials at Stn. 15+00 to 36+40
62+80 - 109+00	depends on amount of rock cut (est. 8,000 cy.)	Silty glaciolacustrine materials at Stn. 62+80 to 68+20
109+00 - 140+00	13,775	Silty glaciolacustrine materials at Stn. 62+80 to 68+20
142+00 to 150+00	2,130	Cuts and sub-excavation between Stn. 168+00 and 407+00
150+00 to 164+00	19,680	Cuts and sub-excavation between Stn. 168+00 and 407+00
164+00 to 178+00 (fill only)	8,710	Cuts and sub-excavation between Stn. 168+00 and 407+00
214+00 to 238+00 (upper 100 ft. of fills only)	8,890	Cuts and sub-excavation between Stn. 168+00 and 407+00
291+50 to 309+00	11,425	Cuts and sub-excavation between Stn. 168+00 and 407+00
322+00 to 328+00	5,110	Cuts and sub-excavation between Stn. 168+00 and 407+00
332+80 to 339+00	5,935	Cuts and sub-excavation between Stn. 168+00 and 407+00
407+00 to 421+00	18,275	Cuts and sub-excavation between Stn. 388+00 and 407+00
564+00 to 576+00	6,670[3]	Sub-excavation of tills between 576+00 to 600+00
TOTAL	121,055 cubic yards	

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[1] See Table 3.1.3-1 for specific locations.
[2] For a top dressing one foot thick except where noted.
[3] For 6 inch dressing only.

These too will improve seed germination by creating micro-sites. All surface preparation work should be done while the slopes are being constructed. This will prevent subsequent difficulties of machine access to the slopes.

4.2 Revegetation Methods

The initial erosion-controlling vegetation will be established from seed. Canada Number One seed will be used to minimize the introduction of weed species. Two methods of sowing seed are appropriate to the Rogers Pass Revision: broadcast seeding by hand-held cyclone seeders or by helicopters and by hydro-seeding. Both methods have proved effective in other industrial developments. It is likely that both broadcast seeding and hydroseeding will be used on the grade. The method of seeding will be determined on a site-specific basis.

Seeding rates should be approximately 75 lb/ac. It is important that the initial seeding be effective. It is difficult to establish vegetation on sites which have remained bare for a year or more.

An application of fertilizer should be made at the time of seeding, because results of the soils assessment indicate that low levels of nutrients exist in almost all the area materials. An all-purpose fertilizer such as 19-19-19 (N,P,K) at a rate of about 300 lb/ac should be used. Section 6.0 outlines the criteria for maintenance fertilization.

All woody species will be established from rooted container-grown stock with the exception of brush layers where Willows and Cottonwood will be used. Seeds or cuttings (depending on species) will be collected in the local area to ensure ecotypic (species adapted to the local environment) compatability. Stock will be grown in nurseries.

Planting will be done by hand in a random pattern. Average planting density will vary depending on the species and the visual effect desired. Table 4.2-1 outlines the recommended planting densities for different species in a variety of situations. Evaluations of the survival rates of various species will likely modify future planting densities.

TABLE 4.2-1

PLANTING DENSITIES FOR WOODY SPECIES[1] ROGERS PASS REVISION

Species	Site Situation[2] Closed Forest (moist)	Open Forest (dry)	Avalanche Tracks
Alder	450	450	1500
Cottonwood	450		625
Willows	175		250
Elderberry			175
Thimbleberry	250	175	450
Red-osier Dogwood	175		175
Juniper		175	
Oregon Grape		175	
Kinickinick		450	
Western Hemlock	1000	450	
Western White Pine	175	250	
Lodgepole Pine		650	
Douglas Fir		450	
Engelmann Spruce	450		
Subalpine Fir	450		
Western Red Cedar	450		

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[1] Average density (stems/acre), plantings will be made in a relatively random pattern to simulate natural cover.

[2] Not all species will be planted on any one site. Total number of stems/acre will be in the 1500 to 4500 range depending on the desired density of the final cover.

5.0 RECLAMATION SCHEDULING

Reclamation work will be scheduled to commence when the surface construction work is completed, or, on the large cuts and fills as portions of the sites are completed. Site preparation work will begin as the slopes are being constructed. Revegetation work will be undertaken in the early spring or late fall following construction, so as to allow for establishment of the initial cover within six months of completion of site construction and site preparation. All plantings will be done in the early spring.

By scheduling the reclamation activities in step with construction, visual and other impacts will be minimized. The initial cover will be well established within two years of completion of construction. Woody plants will require from four to eight years to become firmly established.

6.0 RECLAMATION MAINTENANCE

The reclamation design outlined in this report has been developed to minimize the need for repeated maintenance. However, some sites may require remedial maintenance work, which should be conducted on an as-needed basis. Evaluations of reclamation performance should be made at regular intervals throughout the growing season. Any required remedial work should be conducted as soon as possible after the need has been identified.

The use of nitrogen-fixing legumes in the initial seed mixes will reduce the need for repeated fertilizer application on most sites. However, some sites may require additional applications of fertilizer to that given at the time of seeding. As a general rule, sites with coarse textured materials are more likely to require maintenance fertilization than sites with fine textured materials. Maintenance fertilizer should be applied, as required, early in the growing season and in the middle of the growing season in order to supply a steady source of plant nutrients.

Reseeding of sites where, for a variety of reasons, the initial seeding fails should be conducted in the early spring or late fall during the regularly scheduled reclamation operations. Replanting of woody species should be conducted in the early spring.

Site-specific problems such as excess gullying or slumping should be repaired as quickly as possible to reduce the potential for major problems such as major slope failures. Specialized techniques for reclaiming

problems sites can be employed as required. These may include brush layering, live pole drains where living cuttings are bundled together to act as a drain, the use of "hold-grow" fabrics, soil binding sprays and other techniques as appropriate.

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APPENDIX A

1982 RECLAMATION TRIALS ROGERS PASS

(Pages 1 to 12)

INTRODUCTION

This report summarizes the results of reclamation trials, conducted in 1982 in Roger's Pass, B.C. by Norecol Environmental Consultants Ltd. on behalf of CP Rail. Two sets of trials, a spring and a fall set, were established. The spring trials were established on the cuts at Mountain Creek along the existing mainline. The fall trials established at the end of October, were located along the newly constructed access road between Mountain Creek and the East portal of the short tunnel and the East and West portals of the Rogers Pass tunnel. Although the long-term results of the trials will not be known for some time, the preliminary results from the spring trials presented can provide some indications of measures which can be taken for the ultimate reclamation of the current grade revision work.

SITE DESCRIPTIONS

The Mountain Creek cuts are located near the eastern edge of Glacier National Park on the west slopes of the Beaver River valley. This portion of the Park falls into the Interior Western Hemlock Biogeoclimatic zone. The surrounding forest vegetation is composed of Douglas Fir, Lodgepole Pine and some Engelmann Spruce and Western White Pine.

The present cuts were constructed in 1977 as part of the re-alignment of the Mountain Creek bridge. The cuts are composed of kame delta materials. These materials are of a loamy sand texture with numerous cobbles and stones. The coarse texture as well as the relative lack of organic material results in poor plant nutrient retention. Moisture retention is also reduced by the coarse texture and lack of organic materials.

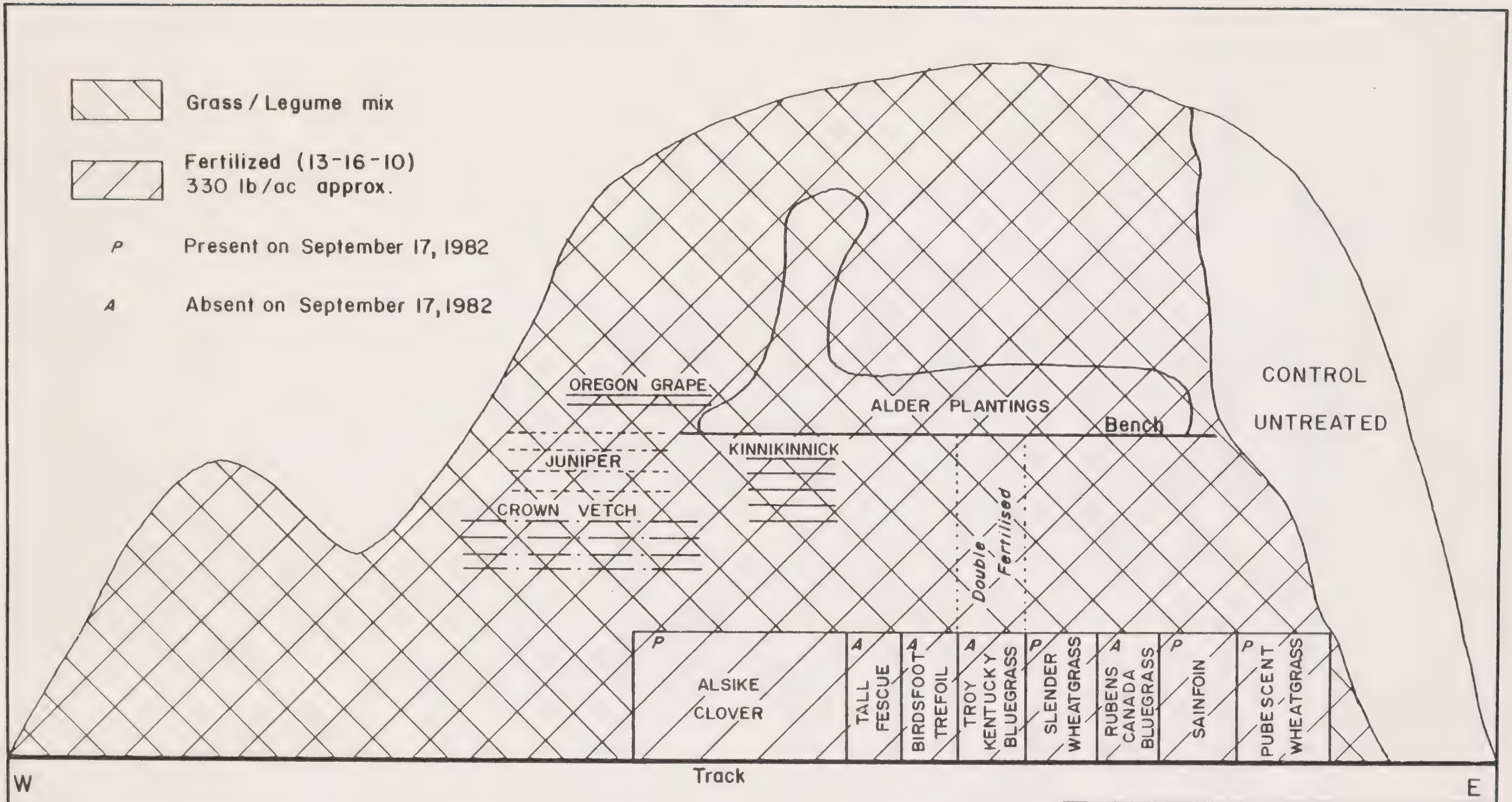
The East cut faces southeast while the West cut has a northeasterly exposure. Slopes range from 30° to 36°. The steep southeast facing slope of the East cut results in excessively dry hot conditions during the summer. Soil temperatures in excess of 120°F have been reported (M. Wakely, pers. comm.) for the East cut. The West cut experiences much less severe conditions due to a more favourable exposure and the presence of groundwater seepage at various locations on the slope.

The new access road is located along the East-facing slope of the Beaver River. In order to test a variety of sites the fall trials were located at eight different sites along the access road. Table 1 lists the site features of these locations.

METHODS

Spring reclamation trials were established on the Mountain Creek cuts during the week of June 8-14. Major emphasis was placed on the East cut as this site is the more severe of the two. A total of 1,765 pounds of fertilizer (13-16-10) and 275 pounds of grass/legume seed mix (Table 2) were spread on the slope. In addition, 110 pounds of 6-24-24 fertilizer was spread on the area near the track where alfalfa and clover dominate. Single species were seeded on a portion of the slope. Alder, Oregon grape, kinnikinnick, juniper and crown vetch were planted on the slope. Figure 1 shows the experimental design for the East cut.

On the West cut, reclamation trials consisted of fertilizing (13-16-10 at about 330 lb/ac) and seeding a portion of the slope with the grass/legume mix. In addition plantings of thimbleberry, alder and red-osier dogwood were made along the base of the slope.



MOUNTAIN CREEK
1982 RECLAMATION TRIALS

figure no.	CP RAIL ROGERS PASS REVISION RECLAMATION PLAN	
1		
date	drawn by	scale
SEPT. 1982	NORECOL	N.T.S

TABLE 1
LOCATIONS AND SITE FEATURES OF FALL TRIALS

Station (approx.)	Site Description	Soils Features
168+00	Small gulley west of Mountain Creek	Wet silt loam
354+00 to 364+00	Steep cuts and fills in in avalanche zones	Loamy sand
400+00 to 414+00	Wet slide area and adjacent side slope	Wet till-like soil and sandy loam
434+00	Gulley west of Stoney Creek	Loamy sand/sandy loam and loam
440+00	Gulley west of Stoney Creek	as 434+00
454+00	Fill slopes adjacent to Soper Creek	Sandy loam/ loamy sand and sand
601+75 (approx.)	East Portal below reinforced earth retaining wall	Sandy loam/silt loam
1070+00 (approx.)	Old drill hole and access near West Portal	Colluvial material, sandy loam

TABLE 2
SEED MIXTURES USED FOR 1982 TRIALS

	Spring Trials (%[1])	Fall Trials (%)
Creeping Red Fescue	8.74	13.20
Hard Fescue	7.26	
Kentucky Bluegrass	0.98	
Streambank Wheatgrass	22.12	
Crested Wheatgrass	18.16	
Orchardgrass	0.73	8.00
Timothy	19.33	36.50
Perennial Ryegrass		29.20
Alsike Clover	9.21	13.10
Rambler Alfalfa	7.17	

[1] by weight

Assessments were made of the vegetation growth on August 11 and 12 and on September 17, 1982. Growth of grasses and legumes was visually estimated. Counts of surviving shrubs were made on August 12. Photographic records were made during each visit.

Fall reclamation trials were established during the week of October 25-28. A total of 1,650 pounds of fertilizer was spread over the eight sites listed on Table 1. Five hundred and fifty pounds of seed was applied to these sites (Table 2). All materials were broadcast with hand-held cyclone seeders. Application rates varied from site to site. On steeply sloping sites, rates were on the order of 100 lb/ac of seed and 300 lb/ac of fertilizer, while on gently sloping or level sites rates were reduced by about half.

The effectiveness of fall seeding as well as species performance will be assessed during the summer of 1983.

RESULTS

This section outlines the results of the spring trials only, because results from the fall trials are not available.

Excessively dry, hot weather conditions (Revelstoke recorded a record (since 1903) high temperature of 32°C on June 14) have affected the survival of some of the planted stock. Table 3 presents survival data for the planted stock. Average cover of the seeded vegetation was 85% in the treated areas. Vegetation cover in the control area averaged about 5%. The presence of single species on the test sites as of September 17, 1982, is indicated on Figure 1. Some species, notably the bluegrasses, are slow to develop. These will be sought in further assessments. Plates 1 through 8 show the results of the trials.

TABLE 3

CP RAIL MOUNTAIN CREEK TRIALS
SURVIVAL OF PLANTED STOCK

	Planted (approx)	Survival %	Living (Aug. 12)
Thimbleberry	100	84%	84 (3 dead plants seen)
Kinnikinnick	100	0%	0
Alder	400	13%	52*
Red-osier Dogwood	50	100%	52
Juniper	100	80%	80
Crown Vetch	100	19%	19
Oregon Grape	50	28%	14
	900	33%	301

* on more mesic sites survival was 100%.

CONCLUSIONS

The use of appropriately chosen grass and legume species can provide a good vegetation cover. Planting times for seeded species should be restricted to late fall (October) or early spring (April-May).

The survival of woody species is affected by the time of planting and weather conditions. Planting of rooted stock should be conducted in the early spring.

Plate 1. View of Mountain Creek Cuts taken June 14, 1982.

Plate 2. View of Mountain Creek taken August 12, 1982. Note control (untreated) area on right side of East (right) Cut.

Plate 3. East Cut on June 14, 1982.
Note planting locations for Juniper and Crown Vetch near centre.

Plate 4. East Cut on September 17, 1982. Dark Green patches are a result of uneven fertilizer spreading due to steep (36° average) slope.

Plate 5. Bench area on East Cut, June 14, 1982. Note coarse texture of material.

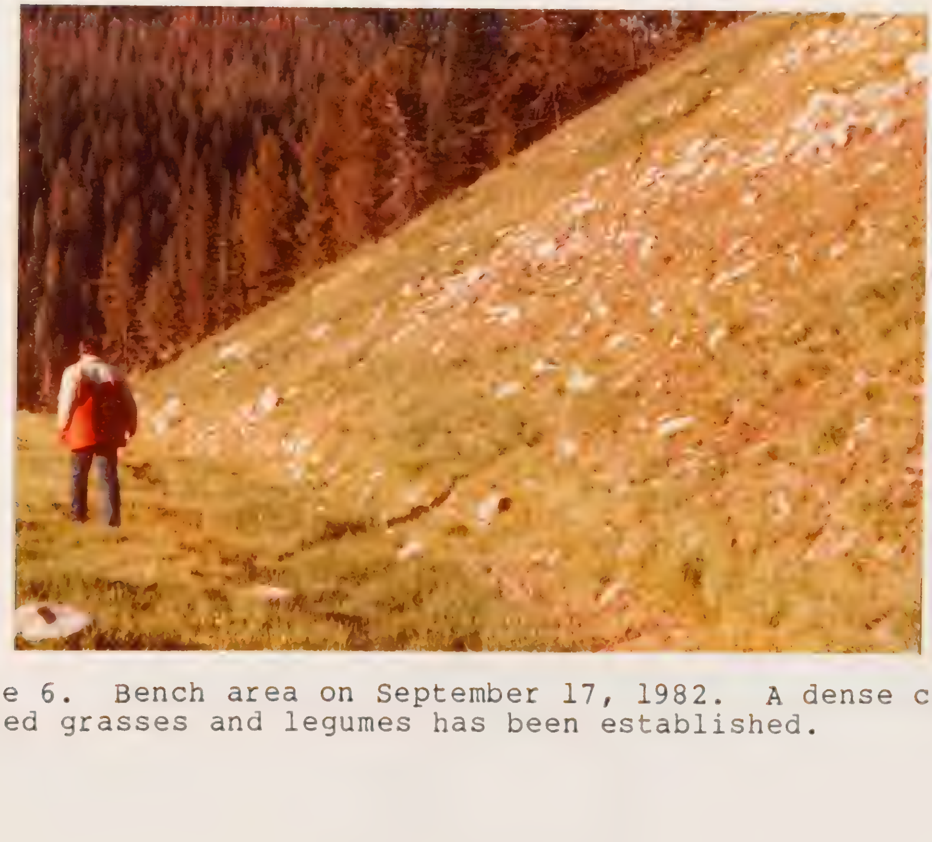


Plate 6. Bench area on September 17, 1982. A dense cover of seeded grasses and legumes has been established.

APPENDIX B

SELECTED CHEMICAL PROPERTIES AND PARTICLE SIZE AND TEXTURE CLASSES OF SOIL MATERIALS

TABLE 1

SELECTED CHEMICAL PROPERTIES OF SOIL MATERIALS

Sample Station Location (approx.)	Sample #	Landform	pH (in water)	E.C. (mmhos/cm)	Total N (%)	Avail P (ppm)	Total C (%)	CEC (me/100 g)	Exchangeable Cations				Base Saturation (%)
									Ca	Mg (me/100 g)	Na	K	
56	NOR 5	Fluvial Terrace	5.8	0.08	0.033	6.9	0.82	8.8	0.33	0.13	0.01	0.05	5.9
65	" 4	Glaciolacustrine	6.1	0.13	0.033	5.0	0.42	4.7	1.38	0.55	0.02	0.12	44.0
104	" 3	Rock & Colluvium	6.0	0.08	0.068	4.2	1.48	17.7	1.30	0.20	0.03	0.23	9.9
118	" 2	Kame Terrace	5.6	0.11	0.050	45.6	0.70	9.1	0.58	0.13	0.01	0.17	9.8
133	" 1	Floodplain	6.6	0.12	0.030	2.2	0.43	4.5	2.65	0.23	0.01	0.05	65.3
185	" 20	Kame Moraine	4.9	0.10	0.027	18.1	0.10	4.9	0.53	0.30	0.02	0.09	19.2
220	" 19	Kame Moraine	5.4	0.08	0.007	6.9	0.01	1.2	0.20	0.08	0.01	0.01	32.5
245	" 18	Slump Material	5.5	0.08	0.023	47.2	0.38	3.6	0.38	0.08	0.02	0.12	16.7
273	" 17	Kame Moraine	5.7	0.11	0.030	7.8	0.66	5.4	1.35	0.18	0.01	0.11	30.5
300	" 16	Kame Delta	5.6	0.08	0.028	16.4	0.11	3.9	0.28	0.08	0.02	0.12	12.8
332	" 15	Rock & Colluvium	6.1	0.16	0.048	2.5	0.82	5.3	4.50	0.48	0.03	0.09	96.2
350	" 14	Kame Moraine	5.6	0.08	0.054	36.7	1.16	12.2	1.10	0.20	0.03	0.01	11.7
400	" 13	Lateral Moraine	5.7	0.13	0.007	6.9	0.01	1.9	0.45	0.13	0.07	0.17	43.1
400	" 12	Lateral Moraine	5.8	0.11	0.031	18.6	1.24	7.8	1.23	0.08	0.02	0.10	18.3
424	" 6	Debris Cone	7.0	0.28	0.019	2.8	0.50	2.3	2.35	0.38	0.01	0.05	118.7
430	" 7	Lateral Moraine	5.7	0.12	0.011	10.6	0.20	3.2	0.30	0.08	0.01	0.06	14.1
430	" 8	Lateral Moraine	5.7	0.08	0.062	20.8	1.88	13.8	0.85	0.15	0.02	0.25	9.2
430	" 9	Lateral Moraine	5.9	0.09	0.013	4.7	0.01	2.6	0.98	0.33	0.02	0.06	53.5
495	" 10	Lateral Moraine	5.9	0.08	0.060	4.4	2.61	23.8	1.58	0.28	0.02	0.12	8.4
495	" 11	Lateral Moraine	5.9	0.08	0.018	43.6	0.17	4.1	0.45	0.10	0.01	0.11	16.3
585	" 21	Lateral Moraine	6.2	0.10	0.030	13.0	0.5*	7.9	1.75	0.07	0.02	0.05	23.9
585	" 22	Lateral Moraine	5.8	0.06	0.070	3.0	1.7*	15.9	1.00	0.01	0.02	0.10	7.1
Existing Mt.Creek Cut Slope	" 23	Kame Delta	7.9	0.38	0.010	14.0	0.3*	1.7	5.00	0.12	0.01	0.08	306.5
	" 24	Kame Delta	8.1	0.57	0.010	3.0	0.3*	0.8	3.75	0.14	0.01	0.05	493.7

* % organic carbon

Source: Norecol Environmental Consultants Ltd.

TABLE 2

SOIL PARTICLE SIZE AND TEXTURE CLASSES

Sample-station Location (approx.)	Sample #	Landform	Coarse Fragments (%)	Sand (%)	Silt (%)	Clay (%)	Texture
56	NOR 5	Fluvial Terrace	43	80.6	17.9	1.5	Loamy Sand
65	" 4	Glaciolacustrine	0	5.3	81.7	13.0	Silt Loam
104	" 3	Rock-Colluvium	16	40.3	56.2	3.5	Silt Loam
118	" 2	Kame Terrace	43	41.4	53.4	5.2	Silt Loam
133	" 1	Floodplain	52	81.3	17.8	0.9	Loamy Sand
185	" 20	Kame Moraine	0	15.8	71.9	12.3	Silt Loam
220	" 19	Kame Moraine	60	92.4	6.4	1.2	Sand
245	" 18	Slump Material	65	56.9	39.7	3.4	Sandy Loam
273	" 17	Kame Moraine	61	61.1	35.4	3.5	Sandy Loam
300	" 16	Kame Delta	16	34.3	57.0	8.7	Silt Loam
332	" 15	Rock-Colluvium	61	84.5	14.0	1.5	Sand
350	" 14	Kame Moraine	64	75.5	22.2	2.3	Loamy Sand
400	" 13	Lateral Moraine	30	59.8	35.5	4.7	Sandy Loam
400	" 12	Lateral Moraine	30	56.8	38.1	5.1	Sandy Loam
424	" 6	Debris Cone	43	63.7	33.0	3.3	Sandy Loam
430	" 7	Lateral Moraine	64	82.8	15.2	2.0	Loamy Sand
430	" 8	Lateral Moraine	43	57.1	40.0	2.9	Sandy Loam
430	" 9	Lateral Moraine	33	50.3	44.8	4.9	Sandy Loam
495	" 10	Lateral Moraine	36	62.1	36.1	1.8	Sandy Loan
495	" 11	Lateral Moraine	62	66.8	29.0	4.2	Sandy Loam
585	" 21	Lateral Moraine	-	64.7	32.8	2.5	Sandy Loam
585	" 22	Lateral Moraine	-	68.0	29.3	2.7	Sandy Loam
Existing Mt.	" 23	Kame Delta	-	79.8	19.1	1.1	Loamy Sand
Creek Cut Slope	" 24	Kame Delta	-	81.0	18.5	0.5	Loamy Sand

Source: Norecol Environmental Consultants Ltd.

APPENDIX C

SOIL PARTICLE SIZE AND TEXTURE CLASSES
(From Thurber Consultants Ltd., 1983)

TABLE 1

SOIL PARTICLE SIZE AND TEXTURE CLASSES

Station	Sample ID	Estimated Coarse Fragment Content (%)	% Sand (2-0.05 mm)	% Silt (0.05-0.002 mm)	% Clay (L0.002 mm)	Texture
145+00	GBTR 101	70	88	7	3	Sand
160+10	ILG 1	60	96	4	0	Sand
166+75	GBT 103	15	48	47	5	Sandy Loam
172+50	GBT 111	35	43	56	1	Silt Loam
173+10	GBT 112	0	13	82	5	Silt
180+00	ILG 2	40	75	25	0	Loamy Sand
182+50	GBT 113	40	93	7	0	Sand
184+90	GBT 114	40	95	5	0	Sand
188+00	GBT 115	0	27	73	0	Silt Loam
188+00	ILG 3	5	27	67	6	Silt Loam
188+90	GBT 117	35	68	31	1	Sandy Loam
195+00	ILG 4	60	86	14	0	Sand
220+00	ILG 5	45	95	5	0	Sand
235+20	ILG 6	60	55	42	3	Sandy Loam
239+10	ILG 7	55	57	43	0	Sandy Loam
252+40	ILG 8	50	71	29	0	Loamy Sand
268+30	ILG 9	45	71	29	0	Loamy Sand
299+00	ILG 10	50	57	36	7	Sandy Loam
301+50	ILG 11	42	23	69	8	Silt Loam
306+15	ILG 12	45	90	10	0	Sand
353+00	ILG 13	30	70	29	1	Loamy Sand
358+25	ILG 14	50	71	27	2	Loamy Sand
362+50	ILG 15	42	73	21	6	Sandy Loam
370+00	ILG 16	35	74	26	0	Loamy Sand
373+50	ILG 17	50	66	32	2	Sandy Loam
378+00	ILG 18	30	46	50	4	Sandy Loam
402+00	ILG 19	30	55	41	4	Sandy Loam
409+00	ILG 20	75	78	7	15	Sandy Loam
419+00	ILG 21	60	82	13	5	Loamy Sand
423+00	ILG 22	50	77	18	5	Loamy Sand
429+00	ILG 23	35	68	31	1	Sandy Loam
433+00	DGR 1	35	51	35	14	Loam
438+00	DGR 3	45	64	26	10	Sandy Loam
440+00	DGR 4	55	71	27	2	Loamy Sand
442+00	DGR 5	40	45	52	3	Silt Loam

TABLE 1

Station	Sample ID	Estimated Coarse Fragment Content (%)	% Sand (2-0.05 mm)	% Silt (0.05-0.002 mm)	% Clay (L0.002 mm)	Texture
440+00	DGR 6	50	88	12	0	Sand
446+00	DGR 7	52	95	5	0	Sand
448+00	DGR 8	55	93	7	0	Sand
450+00	DGR 9	50	71	28	1	Loamy Sand
452+00	DGR 10	55	81	10	9	Loamy Sand
454+00	DGR 11	70	66	21	13	Sandy Loam
456+00	DGR 12	60	75	23	2	Loamy Sand
458+00	DGR 55	55	84	10	6	Loamy Sand
460+00	DGR 14	50	72	26	2	Loamy Sand
463+00	DGR 15	50	62	16	22	Sandy Loam
464+00	DGR 16	50	74	26	6	Loamy Sand
467+00	DGR 17	55	62	25	13	Sandy Loam
469+00	DGR 18	60	75	18	7	Sandy Loam
471+00	DGR 19	45	63	34	3	Sandy Loam
473+00	DGR 20	50	57	42	1	Sandy Loam
475+00	DGR 21	50	62	35	3	Sandy Loam
477+00	DGR 22	55	72	26	2	Loamy Sand
479+00	DGR 23	55	77	21	2	Loamy Sand
481+00	DGR 24	60	76	22	2	Loamy Sand
483+00	DGR 25	15	43	52	5	Silt Loam
485+00	DGR 26	55	70	30	0	Loamy Sand
486+00	DGR 27	60	91	9	0	Sand
488+00	DGR 28	40	37	48	15	Loam
490+00	DGR 29	55	88	12	0	Sand
492+00	DGR 30	80	65	28	7	Sandy Loam
494+00	DGR 31	50	71	29	0	Loamy Sand
495+00	DGR 32	50	68	31	1	Sandy Loam
498+00	DGR 33	50	66	31	3	Sandy Loam
586+50	GBT 603	50	52	45	3	Sandy Loam
588+10	GBT 604	0	45	55	0	Silt Loam

Source: Thurber Consultants Ltd.

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